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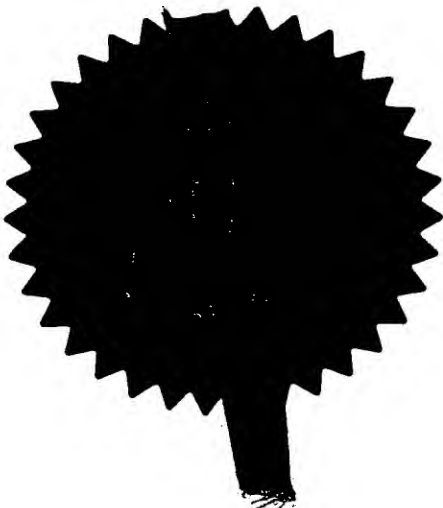
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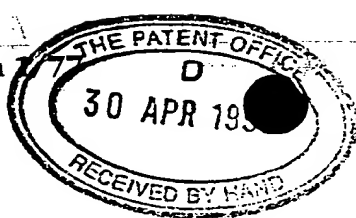
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1. Your reference 87677/KCS/DG

2. Patent application number  
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30 APR 1999

3. Full name, address and postcode of the or of each applicant (underline all surnames)

NOKIA TELECOMMUNICATIONS OY  
KEILALAHDENTIE 4  
02150 ESPOO  
FINLAND

Patents ADP number (if you know it)

6208193006

If the applicant is a corporate body, give the country/state of its incorporation

FINLAND

4. Title of the invention

HANDOVER IN A COMMUNICATION SYSTEM

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

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WC1N 2LS

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1255003  
Country

Priority application number  
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Date of filing  
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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

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HANDOVER IN A COMMUNICATION SYSTEM

The present invention is related to handovers in a communication system and particularly, but not exclusively, to mobile telephone station handovers in an IP-based telecommunications network.

10

Prior art office-based communications systems usually operate conventional fixed-line telephone units linked via an internal switchboard or PBX (private branch exchange.) Such fixed-line systems are able to provide relatively high voice quality. However, user mobility is severely impaired.

15

The advent of digital mobile technologies such as GSM, however, means that mobile systems can now provide equivalent, if not higher, voice quality than fixed-line systems. Mobile systems also allow greater freedom of movement for the user within the office than do fixed-line systems.

20

WIO (Wireless Intranet Office) is a proprietary communications system developed by the applicants which introduces the concept of utilising mobile telephone units, such as conventional GSM mobile stations, in an office environment. The system makes use of a known concept called Internet Telephony or Voice-over-IP.

25

Voice-over-IP is a technology which allows sound, data and video information to be transmitted over existing IP-based Local or Wide Area Networks or the Internet. The technology thus provides for convergence and integration of three different media types over the same network.

30

Prior to the advent of Voice-over-IP, offices often operated three separate networks for the transmission of these media types. As indicated above, fixed-line telephone systems coupled to an in-house PBX provided for voice communication, an office-based LAN or Intranet (i.e. a packet-switched internal network), comprising computer terminals linked via network cards and under the control of a server station, provided for the transmission

35

40

5 of "conventional" computer data and video cameras linked to  
monitors via fixed line or remote transmission link provided for  
video communication.

10 Voice-over-IP effectively combines these three media types such  
that they can be transmitted simultaneously on the same packet-  
switched network or IP-router throughout the office environment  
and beyond the confines of the office.

15 In order to provide for such media convergence, Voice-over-IP  
often uses a specific ITU (International Telecommunication Union)  
standard protocol to control the media flow over the Intranet.  
One common standard protocol used in Voice-over-IP systems, and  
the one used in the WIO system, is termed H.323.

20 H.323 is an ITU standard for multimedia communications (voice,  
video and data) and allows multimedia streaming over conventional  
packet-switched networks. The protocol provides for call  
control, multimedia management and bandwidth management for both  
25 point-to-point (2 end-users) and multipoint (3 or more end-users)  
conferences. H.323 also supports standard video and audio codecs  
(compression/decompression methods such as MPEG) and supports  
data sharing via the T.120 standard.

30 Furthermore, H.323 is network, platform and application  
independent allowing any H.323 compliant terminal to operate in  
conjunction with any other terminal.

The H.323 standard defines the use of three further command and  
control protocols:

- 35
- a) H.245 for call control;
  - b) Q.931 based protocol for call signalling; and
  - 40 c) The RAS (Registrations, Admissions and Status) signalling  
function.

5

The H.245 control protocol is responsible for control messages governing the operation of the H.323 terminal including capability exchanges, commands and indications. Q.931 is used to set up a connection between two terminals. RAS governs registration, admission and bandwidth functions between endpoints and gatekeepers (defined later).

10

For a H.323 based communication system, the standard defines four major components:

15

1. Terminal

2. Gateway

20

3. Gatekeeper

4. Multipoint Control Unit (MCU)

25

Terminals are the user end-points on the network, e.g a telephone or fax unit or a computer terminal. All H.323 compliant terminals must support voice communications, but video and data support is optional.

30

Gateways connect H.323 networks to other networks or protocols. For an entirely internal communications network, i.e. with no external call facility, gateways are not required.

35

Gatekeepers are the control centre of the Voice-over-IP network. It is under the control of a gatekeeper that most transactions (communication between two terminals) are established. Primary functions of the gatekeeper are address translation, bandwidth management and call control to limit the number of simultaneous H.323 connections and the total bandwidth used by those connections. An H.323 "zone" is defined as the collection of all terminals, gateways and multipoint-control units (MCU - defined below) which are managed by a single gatekeeper.

40

5 Multipoint Control Units (MCU) support communications between  
three or more terminals. The MCU comprises a multipoint  
controller (MC) which performs H.245 negotiations between all  
terminals to determine common audio and video processing  
capabilities, and a multipoint processor (MP) which routes audio,  
10 video and data streams between terminals.

The conventional Voice-over-IP system described herein above  
normally utilise standard fixed-line telephone systems which are  
subject to the disadvantages outlined above, namely the lack of  
15 mobility and the lack of user commands.

The WIO concept takes Voice-over-IP further in that it provides  
for the use of conventional mobile telephone units, such as GSM  
mobile stations, within the Voice-over-IP system. To provide for  
20 such mobile communications within an intra-office communication  
network, WIO combines known Voice-over-IP, as described above,  
with conventional GSM-based mobile systems.

Thus, intra-office calls are routed through the office intranet  
25 and extra-office calls are routed conventionally through the GSM  
network. Such a system provides most or all of the features  
supported by the mobile station and the network such as telephone  
directories, short messaging, multiparty services, data calls,  
call barring, call forwarding etc. WIO, therefore, provides for  
30 integrated voice, video and data communications by interfacing  
an H.323-based voice-over-IP network with a GSM mobile network.

The WIO system is a cellular network, similar to the conventional  
GSM network and is divided into H.323 Zones as described above.  
35 One H.323 Zone may comprise a number of (GSM) radio cells. Two  
or more H.323 zones may be contained within an administrative  
domain. The allocation of H.323 zones to an administrative  
domain is an issue primarily concerning billing and is therefore  
not relevant to this invention.

40 Given the cellular nature of the WIO system, a major issue to be



5 solved is that of handovers. As a mobile station moves from one  
cell to another it reports its location to a base station or  
equivalent controller. When it moves from one zone to another,  
a handover is required of the call to another controller. A  
similar consideration applies to mobile stations in the  
10 conventional GSM network.

In such conventional GSM systems, the need for a handover of a  
mobile station to a different cell of the network is normally  
determined by a number of parameters but predominantly including  
15 the mobile station measuring the strength of signals transmitted  
from several base transceiver stations.

During the time that it is in a particular cell, the mobile  
station continuously receives signals from several base  
20 transceiver stations in adjacent cells and compares the signal  
strength of the signals received from each of these stations.  
If the level of a signal transmitted by a base transceiver  
station, located in a different cell from that of the mobile,  
reaches a certain threshold level  $T_1$  in relation to that of the  
25 base transceiver station located in the mobile station's current  
cell, the WIO network may determine that a handover to that cell  
is required and will issue a handover request to the network  
controller (mobile services switching centre).

30 In a similar manner, a mobile station operating in the WIO system  
is able to compare the signal strengths of the signals received  
by several base stations, in different cells, in the network.

However, added complexities arise for handovers in the WIO system  
35 since a mobile unit operating therein must not only be able to  
move between cells within the WIO system, but also between zones  
and even between the WIO system itself and an external GSM  
network.

40 It can be seen, therefore, that there are several different types  
of handovers which may need to be executed in the normal

5 operation of a WIO system. These types of handovers are:

- a) The handover of a mobile from one WIO cell to another.
- b) The handover of a mobile from one WIO zone to another.
- 10 c) The handover of a mobile from a cell within the WIO system to a cell within an external GSM system.
- d) The handover from a cell within an external GSM system to  
15 a cell within the WIO system.

A particular problem to be solved when implementing a WIO system is that outlined in item c) above; that is, to provide for handover of a mobile station from the WIO system to an external  
20 network such as GSM; particularly in situations where the initial call was a WIO internal call (i.e. the call was set up in the WIO system itself).

As will be described later, in such a situation, the initial call  
25 set up is made entirely within the WIO system by the system components. No information regarding the call or the mobile stations involved in the call is transmitted outside of the WIO system.

30 It is apparent, therefore, that any external network, for example a GSM network, and in particular the main network controller within that network such as the Mobile Switching Centre (MSC), are entirely unaware of the existence of the call. No  
information regarding the identity of the calling mobile  
35 stations, the call channels or the location of the calling mobile stations is received by the main network controller.

As a consequence, therefore, if one of the calling mobile  
stations moves out of a cell of the WIO system and into a cell  
40 of an external network, the main network controller of the external network will be unable to perform a handover until such

5 time as it has established all of the information required to  
perform the handover, such as those listed above. The  
establishing of this information takes a relatively long time  
during which the mobile station and the terminal with which it  
10 is in communication are continuously transmitting and receiving  
data packets. If the time to execute the handover is too long,  
data packets will be lost and voice communication will be  
significantly impaired.

15 In order to reduce the time needed to execute a handover of a  
mobile station to an external network and thus to prevent such  
unwanted impairment of the call, a method is needed to provide  
for early notification of an impending handover to the external  
main network controller such that the main network controller is  
able to commence set up of the call handover in advance of the  
20 handover request actually being made.

According to one aspect of the present invention there is  
provided a method of handing off a mobile station from an  
internal cellular communications network to an external cellular  
25 communications network having a network controller, the method  
comprising: allocating at least one cell of the internal cellular  
network as a border cell; detecting the movement of said mobile  
station into said border cell; generating an advance hand-off  
request in accordance with a prediction algorithm which uses a  
30 set of predetermined parameters associated with said mobile  
station and determines when a hand-off is likely to be required;  
and responsive to said advance hand-off request setting up a  
communication channel in the external cellular communications  
network for use by said mobile station when an actual hand-off  
35 request is made.

According to a further aspect of the present invention there is  
provided a network controller for use in an internal cellular  
communications network which comprises a plurality of cells and  
40 including at least one border cell adjacent cells of an external  
cellular communications network having an external network

5 controller, the internal network controller comprising: means for  
detecting the movement of said mobile station into said border  
cell; means for selectively issuing a hand-off advance request  
advising said network controller of said external network that  
10 a hand-off is likely to be required in accordance with a  
predetermined algorithm which uses a set of predetermined  
parameters associated with said mobile station; and means for  
setting up a communication channel in the external communications  
network for use by said mobile station when an actual hand-off  
request is made.

15 In particular, where the internal cellular communications network  
comprises a base transceiver station in RF communication with  
said mobile station, up-link and/or down-link timing advance  
information may be used to estimate the movement of said mobile  
20 station to assist in predicting when to issue a hand-off advance  
request.

When a hand-off request is issued by said mobile station, hand-  
off is implemented in accordance with a communication channel  
25 which has been set up by the network controller of said external  
network responsive to the hand-off advance request.

Thus, call set up to the surrounding system is begun some time  
before the actual demand for handover.

30 Thus, according to the embodiment of the invention described  
herein, when a local telephone call is going on between two  
subscribers in a WIO location area, it is possible for  
subscribers to make a handover to a surrounding public GSM  
35 network. A call set-up is done some time before the actual  
demand for the handover. A special prediction for the demand is  
calculated in the local WIO system and handover preparation is  
started early enough for the MSC of the GSM network to make  
required arrangements for the handover. In the WIO system, some  
40 cells are defined as border area cells. A prediction algorithm  
is used to calculate a demand for handover to the surrounding

5 network. In addition to normal handover parameters like up-link and down-link information, timing advance can be used to estimate a subscriber movement and the need for this kind of handover.

10 For a better understanding of the present invention, and to show how the same may be carried into effect, the present invention will now be described in more detail with reference to the accompanying drawings in which:

15 Figure 1a is a block diagram showing some of the components used in the implementation of a WIO system;

Figure 1b is a block diagram illustrating the communication pathways used during a call between an internal mobile station and an external mobile station;

20 Figure 1c is a block diagram illustrating the communication pathways used during a call between two internal mobile stations operating under the same gatekeeper;

Figure 1d is a block diagram illustrating the communication pathways used during a call between two internal mobile stations operating under different gatekeepers;

25 Figure 2 shows the cellular nature of the WIO system;

Figure 3 is a block diagram illustrating the communication pathways between components of the WIO system and the GSM network before the mobile;

30 Figure 4 is a block diagram illustrating the communication pathways between components of the WIO system and the GSM network during the mobile handover; and

Figure 5 is a block diagram illustrating the communication pathways between components of the WIO system and the GSM network after the mobile handover.

35 A WIO system can be provided in an office and operator environment based on an IP (Internal Protocol) based LAN (Local Area Networks) 10 which are operable to carry packet form data.

40 One or more mobile stations (MS) 1 communicate, i.e. transmit signals to and/or receive signals from, a base transceiver

5 station (BTS) 2. The base transceiver station 2 used in the WIO  
system is similar to base transceiver stations used in  
conventional GSM mobile communications systems in that it is  
connected to, and operates in conjunction with, a controller.  
10 In a conventional GSM system, the controller is termed a base  
station controller (BSC); in WIO, however, the controller is  
represented by an GSM Radio Access Gateway 3, the function of  
which will be described later.

15 The base transceiver station 2 therefore receives signals  
transmitted by the mobile unit 1 and forwards them to the GSM  
Radio Access Gateway 3. The GSM Radio Access Gateway 3 is also  
connected to the IP-based LAN 10.

20 A WIO Gatekeeper (WGK) 4 is connected to the IP-based LAN 10.

25 WIO allows for the use of mobile telephone in the office  
environment to make both intra- and extra-office calls. The  
functions of each of the components of Figure 1 will now be  
described in more detail.

30 The GSM Radio Access Gateway 3 performs similar functions to that  
of a base station controller in a conventional GSM network such  
as the management of radio resources and channel configuration  
and the handling of the Base transceiver station configuration.  
However, the GSM Radio Access Gateway 3 also provides conversion  
from GSM voice data to packet-based data suitable for  
transmitting on the packet-based LAN.

35 The WIO Gatekeeper 4 is the main controller of the WIO system.  
It is responsible for all of the functions which the H.323  
protocol defines to its gatekeeper, including call management and  
call signalling. The WIO Gatekeeper is able to manage the main  
different call types such as voice, data, facsimile and  
conference calls which can be established between a mobile  
40 station, a computer terminal and a normal telephone in any  
combination.

5 An GSM gateway 8 handles the communication between the WIO environment and the GSM network. It is connected to the Mobile Switching Centre (MSC) of the GSM network. From the MSC viewpoint, the WIO appears to be a conventional base station controller.

10 The telephone calls managed by the WIO system can be divided into internal calls and external calls. Internal calls are those calls where both parties to the call are located within the WIO system, and external calls involve any telecommunication terminal  
15 which is not located within the WIO system.

The functions of the WIO system components described above will now be described, with reference to Figure 1b, in the context of a telephone call from a mobile station located within the WIO  
20 system (mobile A) to a mobile station located in an external network such as a GSM network (mobile B)

The mobile station A transmits a radio frequency (RF) transmission signal TX, on a predetermined RF communication  
25 channel, to the base transceiver station 2 in a format conventional to GSM communications systems such as a time-slot format. The communication channel on which the mobile station A transmits the RF transmission signal TX is determined in a manner conventional to GSM communication systems.

30 The base transceiver station 2 receives the RF transmission signal, down-converts it and then forwards it to the GSM Radio Access Gateway 3. In this respect, the base transceiver station 2 and the GSM Radio Access Gateway 3 operate in a manner similar  
35 to a base transceiver station and a base station controller respectively in a conventional GSM network.

The GSM Radio Access Gateway 3 receives the down-converted transmission signal from the base transceiver station 2 and  
40 converts it from the conventional GSM time-slot format, to a packet-based format which allows it to be transmitted along the

5 LAN or IP based network. This is referred to herein as the  
PAYLOAD. Also, the GSM Radio Access Gateway 3 composes a control  
signal CTRL which includes signalling information, for example,  
identification of the destination mobile unit, the IP address  
corresponding to that mobile unit and/or identification of the  
10 source mobile unit.

The control signal CTRL is then routed, in packet format, via the  
LAN or IP based network, to the Gatekeeper 4 which based on the  
information contained in the control signal CTRL, determines  
15 whether the mobile station B is located within the WIO system or  
external to the WIO system. If the mobile station B lies outside  
the WIO system, e.g. a conventional GSM mobile unit operating in  
the GSM network, the Gatekeeper 4 routes the CTRL signal to the  
GSM gateway 8 via LAN 10 and the corresponding PAYLOAD  
20 information is transmitted in packet format via the LAN 10  
between the GSM gateway 8 and GSM Radio Access Gateway 3. The  
GSM gateway 8 converts the packet-based PAYLOAD to circuit-  
switched time slot information for the mobile services switching  
centre MSC. The MSC then handles the PAYLOAD and the CTRL  
25 information in a manner to a conventional GSM network.

Calls which are completely internal to the WIO system are handled  
slightly differently, as shown in Figure 1c. The RF transmission  
signal TX, in timeslot format, transmitted by the mobile A is  
30 again sent to the BTS 2 which performs down conversion of the  
signal. The down-converted signal is forwarded to the GSM Radio  
Access Gateway 3 which performs format conversion to generate a  
PAYLOAD packet and a control packet CTRL. From the GSM Radio  
Access Gateway 3, the control signal CTRL is sent to the  
35 Gatekeeper 4 which determines if the mobile station B is within  
the WIO system and, if so, in which H.323 Zone it is located.

If the mobile station B is operating in the same H.323 Zone as  
the mobile station A, i.e. under the same Gatekeeper, the  
40 Gatekeeper 4 will receive a paging response signal from the  
destination GSM Radio Access Gateway, i.e. the GSM Radio Access



5 Gateway under which the mobile station B is operating via the LAN 10, and then routes the payload along the LAN 10 to that destination GSM Radio Access Gateway 3.

10 The destination GSM Radio Access Gateway 3 converts the payload signal into a timeslot format. It is then sent, via its base transceiver station which performs up-conversion to RF, to the mobile station B.

15 If the mobile station is in a different H.323 zone to the mobile station A, the gatekeeper 4 routes the payload signal to the destination gatekeeper 4 via the LAN 10. The destination gatekeeper 4 is the one under which the second mobile station B is operating. This scenario is shown in Figure 1d. The destination gatekeeper 4 will also send a paging message to each  
20 GSM radio access gateway 3 under its control. If it receives an acknowledgement from one of the GSM radio access interfaces, it routes the payload signal from the source GSM radio access gateway 3 to the destination GSM radio access gateway via the LAN 10 and out to the mobile station B, via the base station as  
25 described in relation to Figure 1c.

Figure 2 is a diagram showing the cellular nature of the WIO system.

30 Reference numeral 100 represents the office environment denoted by the same numeral in Figure 1 and the perimeter of the box 100 may be considered to represent the wall of the office in which the WIO system is implemented.

35 Within the office, the WIO system provides a cellular communications network, similar to that of a conventional mobile network such as GSM. Within the office 100, therefore, there are a number of cells (A...H). In Figure 2, there are 8 cells configured as squares. The number and shape of the cells  
40 implemented in the WIO system is not restricted to these characteristics, however. They are depicted in Figure 2 in this

5 manner for ease of representation. In fact, the shape of the cells tends to be more hexagonal than either circular or square.

The cells incorporating the entrance/exit(s) of the office (DR1, DR2) - shaded cells E and C in Figure 2 - are defined as border  
10 cells. The function of the border cells will be described later.

Outside of the WIO office 100, there may lie cells of an external network such as a GSM network. In Figure 2 these cells are labelled GSM1 and GSM2. In reality, it is possible that the WIO  
15 office 100 will lie entirely within a cell of the external network. However, for ease of representation, the external cells are shown to be adjacent to and slightly overlapping the border cells E & C.

20 As described above, when a mobile station B which is operating an on-going call to a mobile station A within the WIO office 100, the call having been initiated while both mobiles were within the office, moves out of the office from exit DR2, for example, it moves into the cell GSM2 of the external network.

25 Since the call was initiated entirely within the WIO system, the MSC of the external network of which cell GSM2 forms a part has no knowledge of either the call or the identity of the mobile stations involved therewith. Consequently, when the mobile  
30 station B moves out of the office, its handover to the cell GSM2 will not take place until the Mobile Switching Centre has established its identity and the details of the call in which it is involved.

35 According to the embodiment described herein, therefore, the movement of a mobile station into one of the border cells E, C of the WIO system is used to predict if and when that mobile station will move out of the WIO system and into the external network, thus requiring an external handover.

40 If the mobile moves into one of the border cells of the WIO

5 system, the system begins to generate a prediction as to the likelihood of an external handover being required and when that handover must be requested. The movement of the mobile station is determined by using, for example, timing advance information conventional to GSM systems or any other suitable technique.

10 By using a prediction algorithm in conjunction with one or more of a number of operating parameters listed below, the GSM Radio Access Gateway 3 predicts that a handover to a cell of the external network is likely to be required a certain time (time period  $tp_0$ ) in advance of the handover being required. The GSM  
15 Radio Access Gateway 3 then sends a hand-off advance request, in packet-based format, to its gatekeeper 4 which forwards this message via the LAN and the GSM gateway 8 to the mobile services switching centre of the external network.

20 The mobile services switching centre is able then to begin preparations for the handover of the mobile station before an actual handover requirement is determined by the GSM Radio Access Gateway.

25 In order to generate a prediction as to the likelihood of a possible handover of a mobile to an external network, the prediction algorithm used in the GSM Radio Access Gateway takes into account one or more of the following operating parameters  
30 specific to the mobile station:

- 1) The distance of the mobile station from the edge of the border cell;
- 35 2) The strength of the signal received by the mobile from the border cell's base transceiver station; and
- 3) The strength of the signal received by the mobile from the external cell's base transceiver station.

40 The prediction algorithm uses the above parameters and, based on

5 a probability estimation of a handover being requested by the mobile station, generates an advance handover request earlier than the actual handover request.

10 For "normal" handovers, i.e. handovers between two cells of the WIO system, the GSM Radio Access Gateway 3 sends a handover request message to the Gatekeeper 4 according to predetermined environment reported by the mobile station satisfying a threshold level T1. These may include the relative difference between the level of the received signal transmitted by the current base  
15 transceiver station and the level of the received signal being transmitted by a base transceiver station in a different cell reaching a threshold level TL1..

20 In the present embodiment, the likelihood of a handover being required is predicted and a hand-off advance request is issued if the value generated by the prediction algorithm exceeds a predetermined threshold level T2. As in the case of a "normal" handover described above that value is itself determined by the individual values of one or more of the above listed parameters.

25 For example, subject to no other overriding parameters, the relative difference between the received signal level of the current base transceiver station and the received signal level of a base transceiver station in a different cell may need to  
30 exceed a lower threshold level, TL2, before the prediction algorithm generates a value which exceeds the threshold value T1 required for a hand-off advance message. In other words, the threshold level TL2 for the signal level parameter used, among other parameters, by the prediction algorithm to predict that a  
35 handover is *likely*, is reached before the threshold level TL1 used by the mobile to determine that a handover is *required*.

40 The relative strengths of the signals transmitted by the current base transceiver station and the base transceiver station of the external cell, together with other information such as the speed and direction of motion of the mobile station through the border

5 cell, allows the prediction algorithm to determine that an external handover is likely to be required some time (time period tp0) before the mobile itself determines that such a handover is actually required. Thus the external controller can set up a communication channel in the GSM network ready for the mobile station if it does issue a handover request.

15 Figs 3, 4 and 5 show, respectively, the communication pathways before, during and after a handover. The following description illustrates the handover of mobile station B located in border cell E to external cell GSM2 whilst in communication with mobile station A located in cell A.

20 In this context, the components of cell E, i.e. the cell out of which mobile station B will move, are termed the source components while the components of cell GSM2, i.e. the cell into which mobile station B will move are termed the target components.

25 Before the handover (figure 3), mobile station B communicates with mobile station A by transmitting an RF, timeslot-based signal to the source base transceiver station which down-converts the signal and sends it to the source GSM Radio Access Gateway 3. The source GSM Radio Access Gateway 3 converts the signal into a packet-based format and sends it, via the IP-LAN 10, to the gatekeeper 4. The gatekeeper 4 identifies the destination mobile station as mobile station A and then sends the packet-based signal, via the IP-LAN 10, to the GSM Radio Access Gateway 3 of mobile station A. The GSM Radio Access Gateway 3 converts the signal back into GSM timeslot format and forwards it to its base transceiver station which up converts the signal to RF and transmits it to mobile station A.

40 While the mobile station B is within the border cell E, the source GSM Radio Access Gateway, using one or more of those parameters 1) to 3) listed above in conjunction with a prediction algorithm, generates a prediction as to the likelihood of a

5 handover of the mobile station B from border cell E to external cell GSM2 being required.

10 When the required threshold level T2 of the value generated by the prediction algorithm is met, for example threshold TL2 is reached and it is determined that the mobile station B is moving towards the exit and is likely to require a handover to the GSM network, the source GSM Radio Access Gateway 3 issues a hand-off advance request which is sent to the gatekeeper 4.

15 The gatekeeper forwards this message in packet format via the LAN 10, to the GSM gateway. The GSM gateway converts the handover required indication message into a format recognised by the GSM mobile switching centre, such as a timeslot format, and sends it to the mobile switching centre.

20 The mobile switching centre then begins to set up the required communications links necessary to set up a "dummy" call (Figure 4). In particular, a communication link for the control signals are established between the GSM Radio Access Gateway, the gatekeeper, the GSM gateway and the mobile switching centre.

30 When the mobile station B moves nearer the exit of border cell E and the signal level of the base transceiver station of cell GSM2 reaches threshold level T1, a normal external call is set up (although the mobile station is still inside the WIO) and then a handover request is issued. When handover is about to be performed the "dummy" call is established and the internal call is released. A normal GSM handover procedure is then effected. The payload is transferred between mobile B and mobile A via the  
35 GSM Radio Access Gateway, the GSM gateway and the MSC just before handoff. The MSC handles the handover.

40 The source GSM Radio Access Gateway sends the handover request to the gatekeeper who instructs the mobile station A to execute the handover and then connects the signals from the GSM gateway to the destination base station controller and disconnects the

5 signals from the source GSM Radio Access Gateway. At this point,  
the handover is considered to be completed (Figure 5).

10 In this manner, the mobile station B is handed over from the  
border cell E of the WIO system into a cell GSM2 of an external  
network. Since the external network has advance notification of  
the handover, by virtue of the prediction generated by the source  
intranet mobile cluster interface, the required communications  
links necessary to execute the handover can be set up. When, and  
only when, those links have been set up will the gatekeeper  
15 instruct the mobile station to execute the handover.

Thus, breaks in the packet stream are minimised reducing packet  
loss and improving communications links.

5    CLAIMS:

1.    A method of handing off a mobile station from an internal cellular communications network to an external cellular communications network having a network controller, the method comprising:

10       allocating at least one cell of the internal cellular network as a border cell;

         detecting the movement of said mobile station into said border cell;

15       generating an advance hand-off request in accordance with a prediction algorithm which uses a set of predetermined parameters associated with said mobile station and determines when a hand-off is likely to be required; and

20       responsive to said advance hand-off request setting up a communication channel in the external cellular communications network for use by said mobile station when an actual hand-off request is made.

25    2.    A method according to claim 1, wherein said network controller implements hand-off to said communication responsive to an actual hand-off request.

30    3.    A method according to any preceding claim, wherein said mobile station is in communication with a base transceiver station in the internal cellular communications network prior to hand-off.

35    4.    A method according to claim 3, wherein said predetermined parameters for use by said prediction algorithm includes timing advance information reported from the base station to the mobile station.

40    5.    A method according to any preceding claim, wherein the internal cellular communications network comprises an internal network controller which carries out said prediction and issues said hand-off advance request.



5     6.     A method according to claim 5, wherein said hand-off advance request is issued in packet format via a packet communication path from the internal network controller to said network controller of said external network.

10     7.     A network controller for use in an internal cellular communications network which comprises a plurality of cells and including at least one border cell, said at least one border cell being adjacent cells of an external cellular communications network having an external network controller, the internal  
15     network controller comprising:

         means for detecting the movement of said mobile station into said border cell;

         means for selectively issuing a hand-off advance request advising said network controller of said external network that  
20     a hand-off is likely to be required in accordance with a predetermined algorithm which uses a set of predetermined parameters associated with said mobile station; and

         means for setting up a communication channel in the external communications network for use by said mobile station when an  
25     actual hand-off request is made.

8.     An internal cellular network controller according to claim 7, comprising a base transceiver station operable to set up an RF communication channel with said mobile station.

30     9.     A network controller according to claim 7 or 8, wherein said external network controller is in communication with said internal network controller by a packet communication path for transmission of said hand-off advance request.  
35

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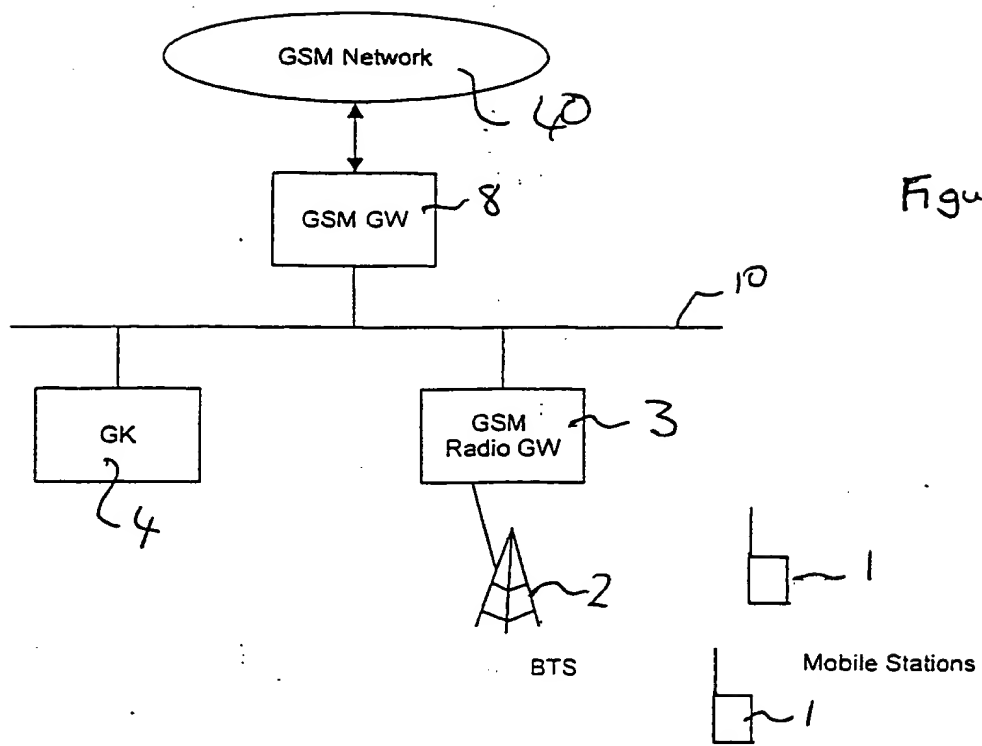
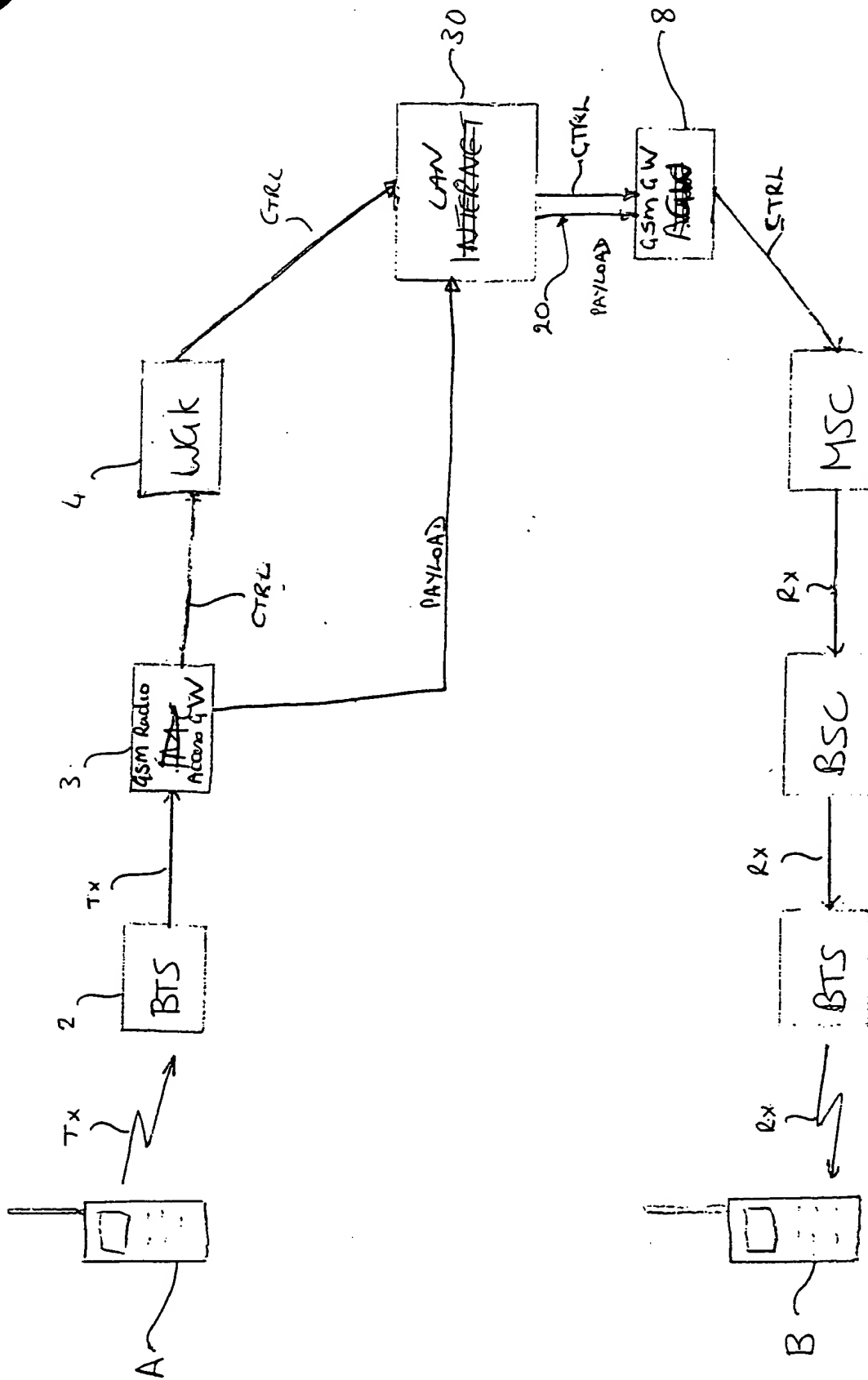


Figure 1a

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internal  
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Fig. 1b.

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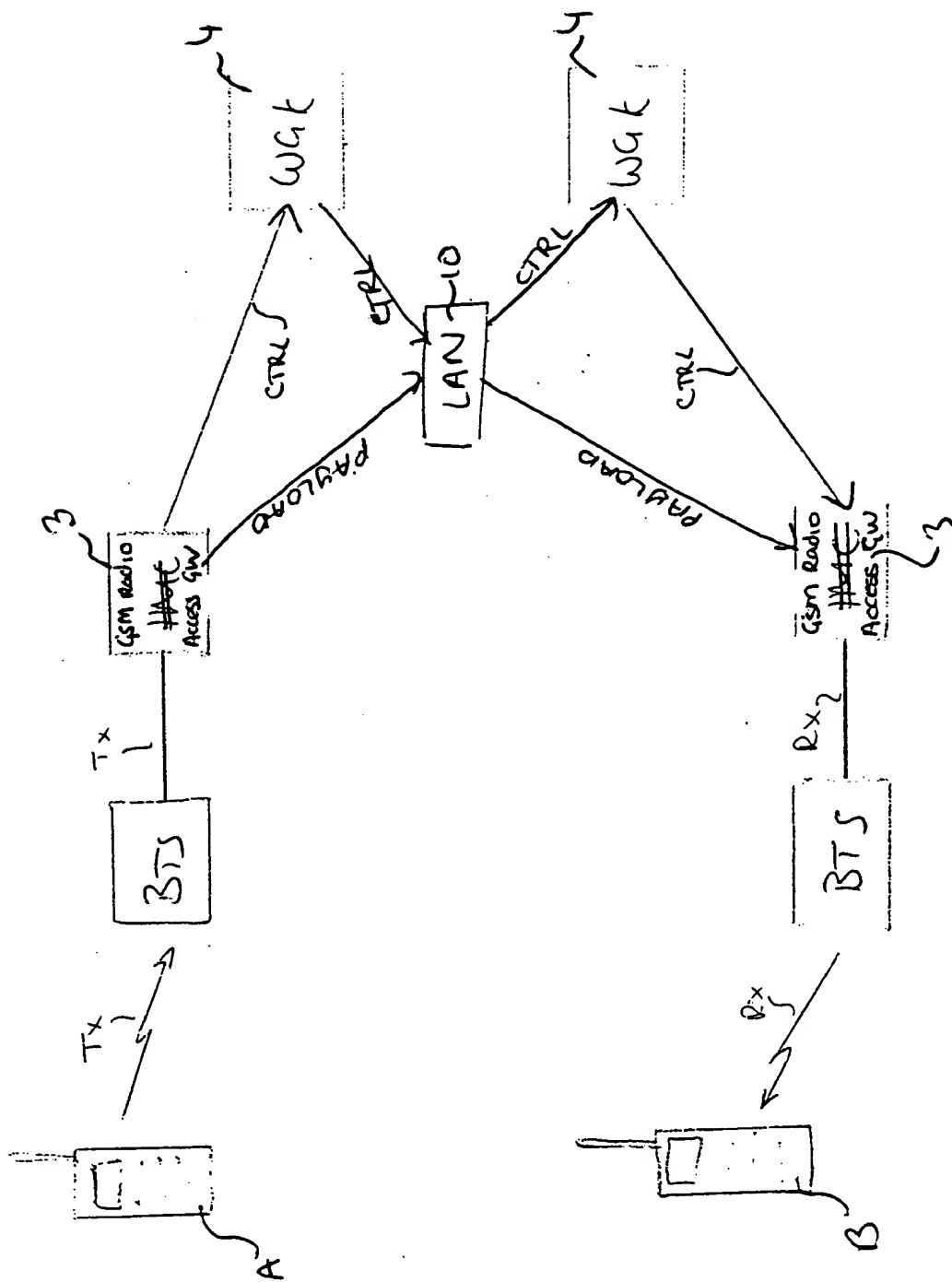


Fig 1 d.

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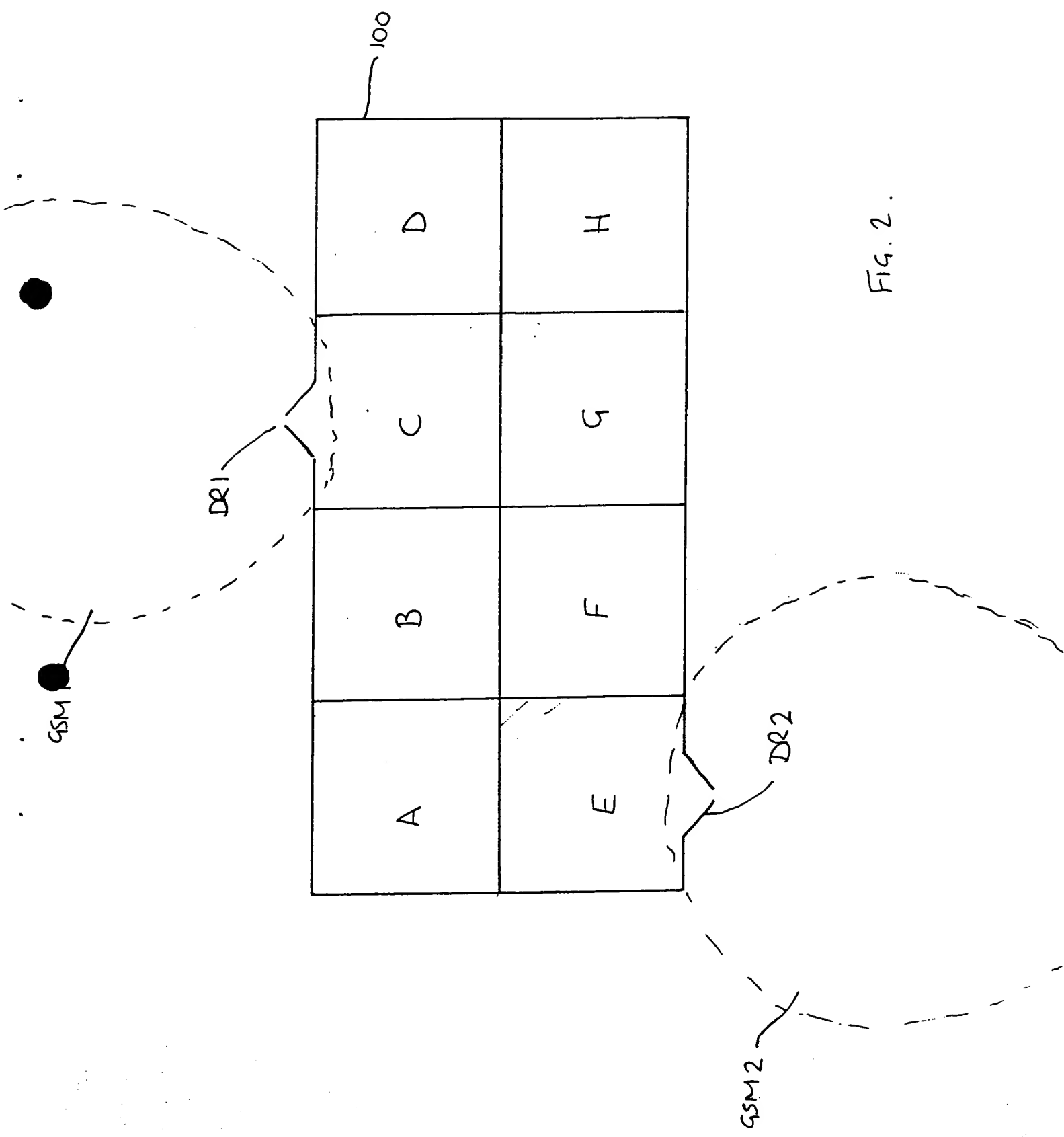


FIG. 2.

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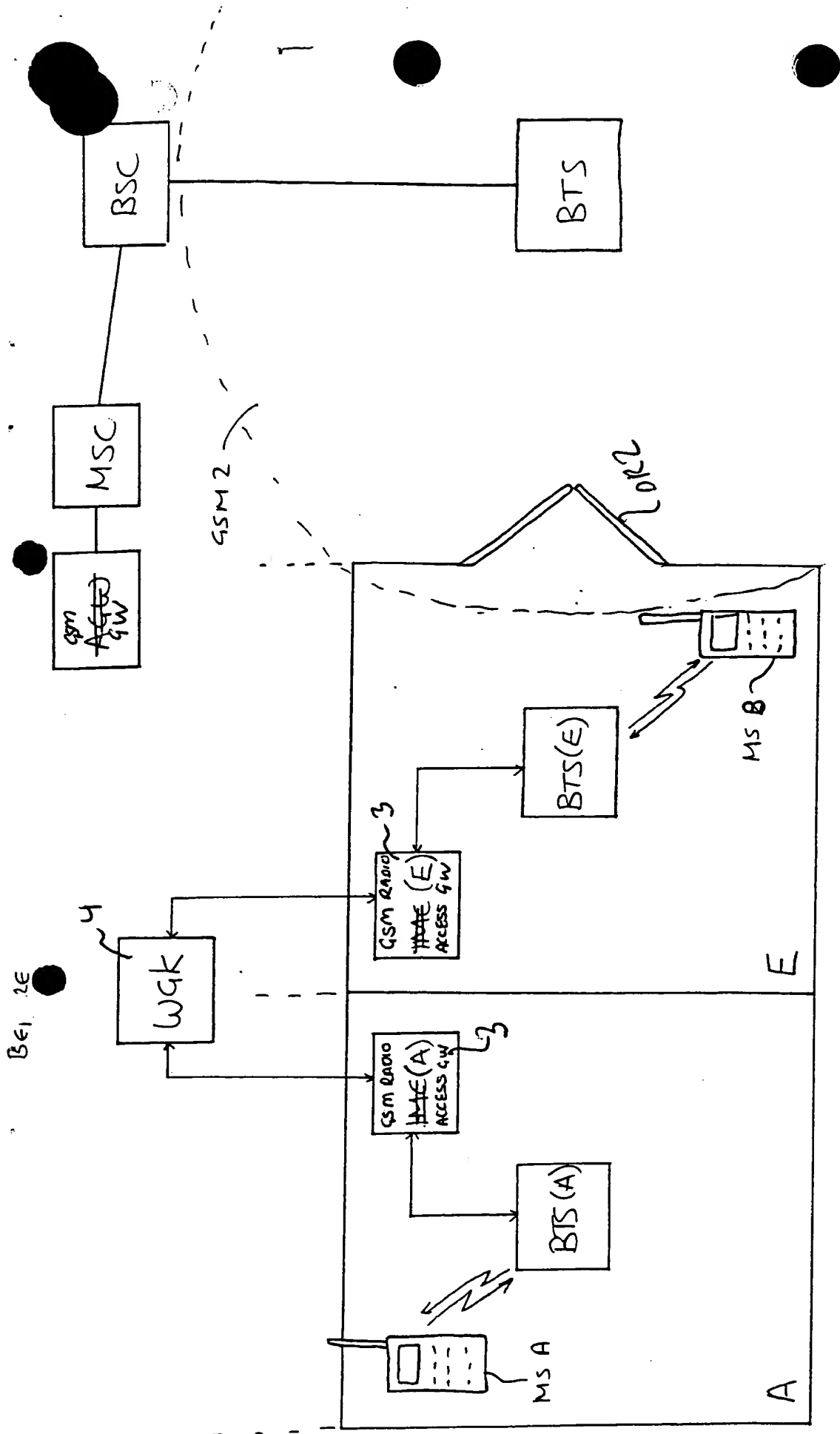


FIG. 3

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During

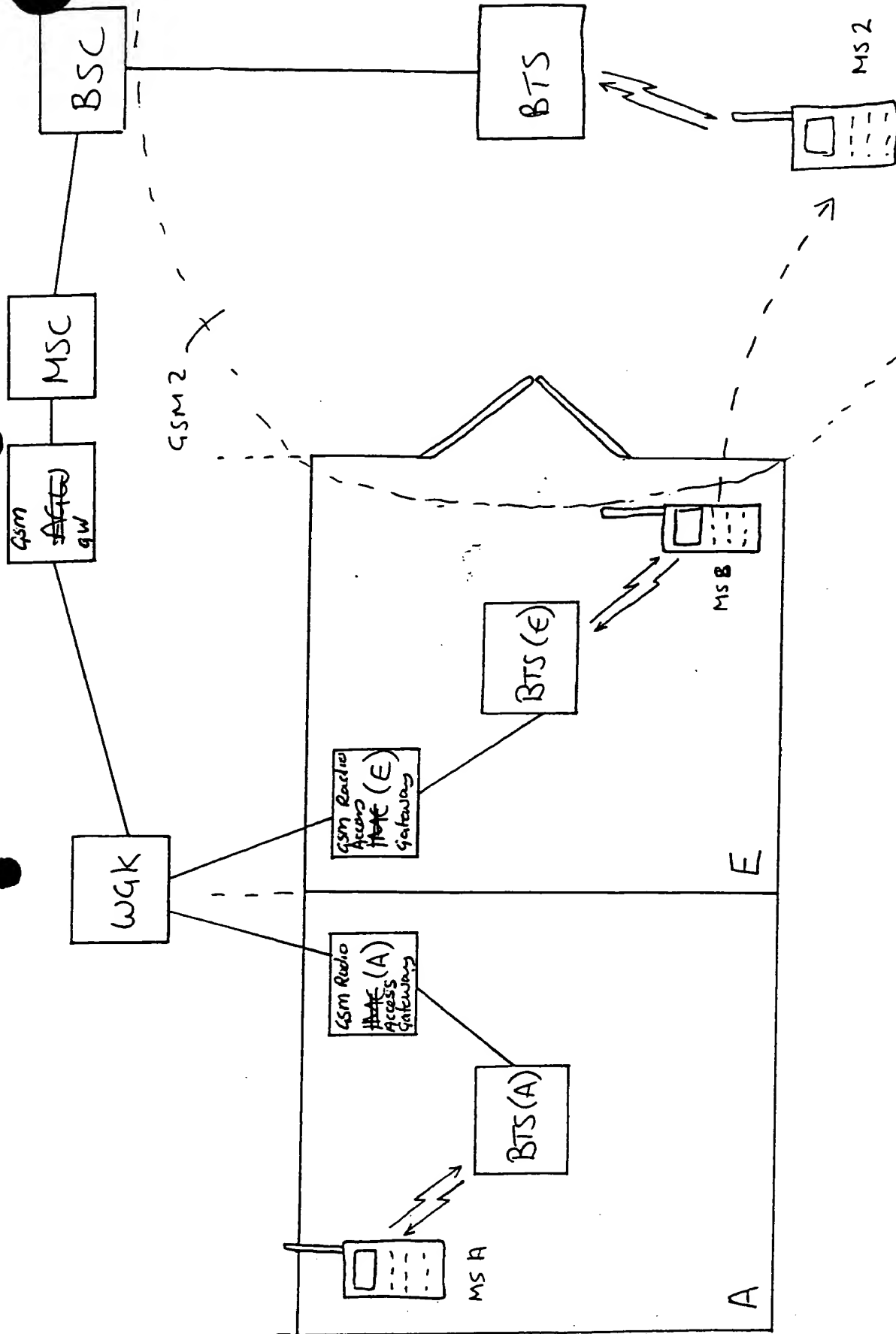


FIG. 4.

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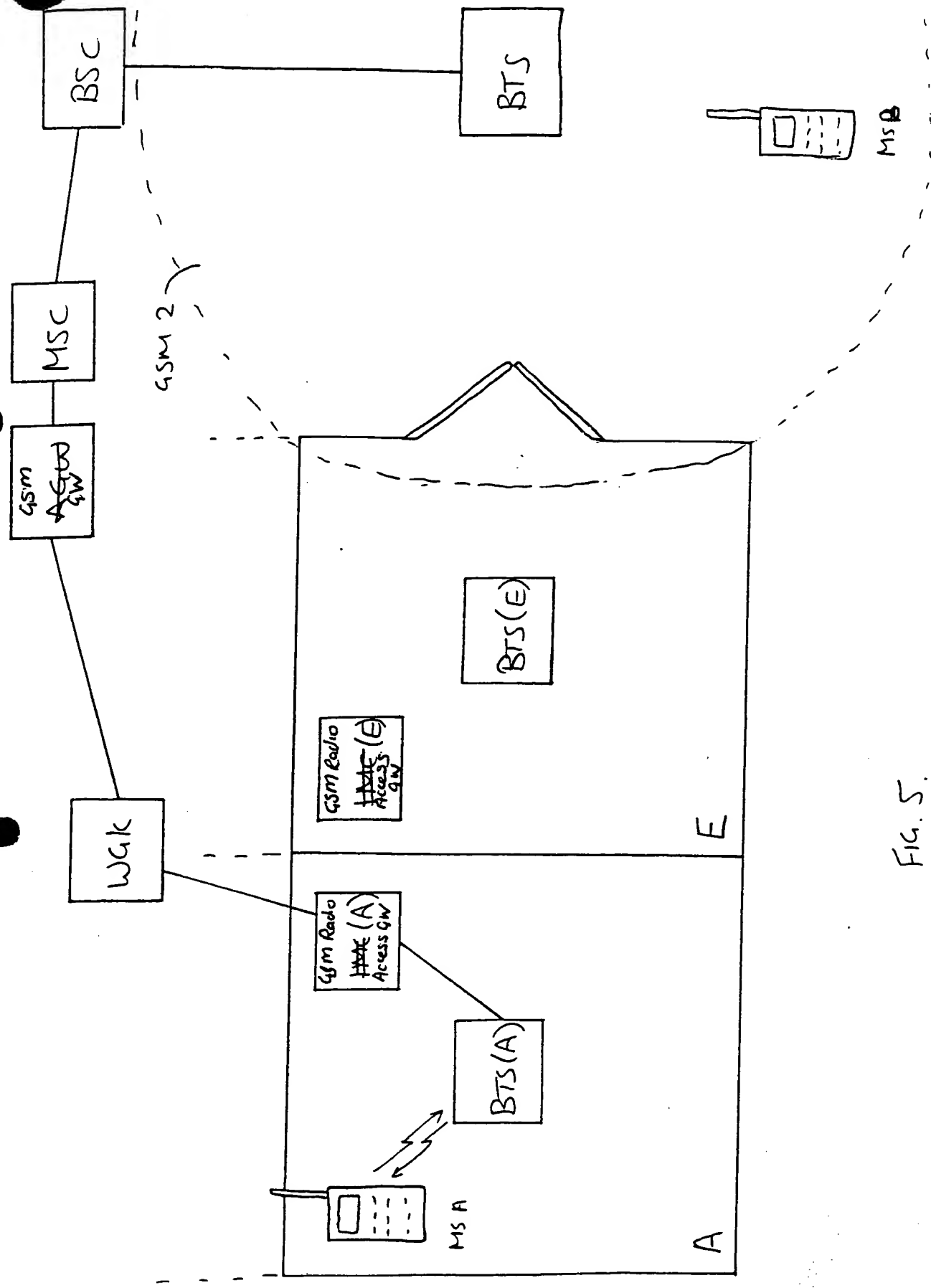


FIG. 5.

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